

In the specification:

Please substitute the following paragraphs for the paragraphs at the indicated locations in the specification as originally filed or most recently amended.

Paragraph [0024]:

As illustrated in Figure 1, a layer 150 is provided (in the case of copper but generally not in the case of aluminum or tungsten) over the M1 layer. This barrier layer is preferably an insulator of silicon nitride, silicon carbide or the like which can function as both a barrier, particularly when a low-k material that is particularly subject to diffusion of moisture is used as the ILD, and an etch stop for the subsequent via level and is sometimes referred to as a cap layer or (somewhat inaccurately) as a copper cap. The ILD layer 160 is then formed and patterned as both a barrier to copper out-diffusion and, particularly, to form the wiring trenches 170 and via openings 180 in accordance with the chip design. The cap layer provides substantial convenience as an etch stop in this process and then opened using the patterned ILD layer as a mask using a process well-understood in the art. Then, as shown in Figure 2, a layer or ~~fill~~ film of alloying material 210 is applied, preferably by sputtering at high temperature, to form an alloy with exposed copper as it is deposited. A high temperature process is much preferred to assure that all alloying material deposited on exposed copper 130 is reacted with the copper as it is deposited, as illustrated at 220, so that no unreacted alloying material will remain at the trench bottom where it might be available to diffuse into and alloy with the copper at a later time.

Paragraph [0026]:

Then, as shown in Figure 3, the barrier layer 310 component of the liner is deposited. The barrier layer is preferably of tantalum, tungsten or titanium or alloys or nitrides thereof (although a barrier of one or more layers of other conductive materials is possible) and should be as thin as possible consistent with providing a barrier to diffusion of the alloying material. Most preferred is a bilayer of TaN/Ta. The barrier layer 310 is then preferably followed by a seed layer 320 and copper 330 to form the dual Damascene conductor and via is applied, preferably by electroplating. The excess metal films remaining on the top surface are removed by chemical mechanical planarization (CMP) back to the ILD layer 160 to complete the conductor layer in accordance with the invention.

Paragraph [0033]:

Further, as shown in Figure 5, this anisotropic etch process also optionally but preferably recesses (415) the copper of conductor ~~420~~ 130 at the trench bottom which increases the area of the copper to copper interface and provides for current to largely bypass the alloy annulus. A tantalum second barrier layer 420' (which may be required to protect the low-k ILD, if used) and a seed layer 430 are then applied as in the first embodiment and copper 440 is applied, preferably by plating (although other processes may allow omission of the seed layer, as is well-understood in the art) and planarized. The second embodiment of the invention is completed by annealing to form an alloy annulus 450 below the sidewalls 410 as shown in Figure 6 where the alloying material contacts the underlying copper, as limited by the barrier layer 420 (and 420'). A sectional view of

the alloy annulus at section A-A is shown in Figure 6A. The annealing can be performed at any time after barrier layer 420 is in place and annealing prior to deposition of the via copper may be preferable in some circumstances.

Paragraph [0039]:

Figure 7 shows an M1 layer topologically identical to that of the first or second embodiments including, in this case, a Damascene conductor 130 supported by an insulator 110. As shown in Figure 8, the copper wiring of the M1 layer is recessed slightly, preferably in the range of 10 to 50 nm or slightly more than the barrier layer required to control diffusion of the alloying material. Then, barrier layer 710 is deposited and a layer of alloying material 720 deposited thereover. Layers 710 and 720 are then planarized by polishing back to the original M1 layer surface or slightly beyond to achieve the desired thickness of alloying material film. The V1/M2 layer is then formed, as shown in Figure 9, by depositing and patterning the ILD 160 and a bottomless liner 740 (where both the TaN and Ta (or other material) barrier layers are sputtered open at ~~at~~ the via bottoms) and copper 330 deposited, preferably by plating after depositing a seed layer, as discussed above. The third embodiment of the invention is then completed by annealing to diffuse and alloy material from layer 720 with copper 330. The annealing should be carried out sufficiently to consume the entirety of layer 720 with copper 330 diffusing into the region 750 above barrier layer 710 surrounding the via while the alloying material diffuses upwardly for only a short distance 730. Thus, as in the first and second embodiments, the alloying is stabilized by consumption of the alloying material and

confined to an extremely thin layer by a thin conductive barrier layer to achieve increased strength at the via/wiring interface without significant compromise of the low resistance provided by the copper wiring.